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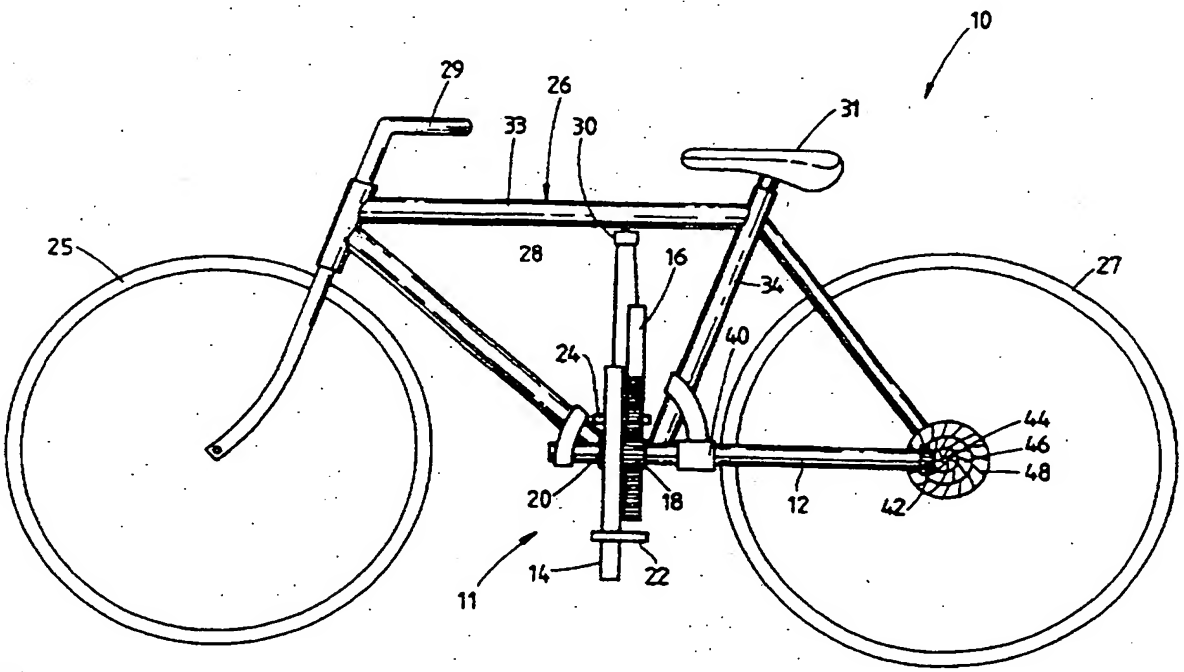


(57) Abstract

A pedal assembly (11, 60) for a manually powered vehicle such as a bicycle (10), the drive assembly including a drive shaft (12), first and second pedals (22, 24), first and second gears (20, 32, 86, 88) which are coupled to transmit driving torque to the drive shaft, the drive assembly including racks and/or chains for coupling the pedals to the gears, the drive assembly being arranged so that the pedals are constrained to execute only reciprocating movement in a linear direction so as to achieve optimum mechanical advantage.

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# A DRIVE MECHANISM FOR A MANUALLY POWERED VEHICLE

The present invention relates to a drive mechanism, and is particularly, though not exclusively, concerned with a drive mechanism for a foot-powered cycle.

For many years the conventional bicycle has provided a convenient means of transport. Over this time a large number of variations to the traditional form have been proposed. These have attempted to, amongst other things, improve durability and efficiency and decrease complexity of the mechanisms required. Few of these proposals, however, have resulted in significant changes to conventional bicycle design.

One area of conventional bicycle design which has been the subject of attempted improvements, is the drive system connecting the pedals with the driving wheel. Conventionally, this has been provided by a chain drive mechanism. Chain drive mechanisms have several problems. For example, over time, the chain has a tendency to stretch causing poor integration with the driving cogs and resulting in chain slippage which is potentially very dangerous. The chain mechanism has an increased susceptibility to rusting, and requires continual maintenance to avoid chain damage.

A further disadvantage of conventional bicycle design exists in the rotary pedalling system. As a result of this circular motion of the pedals, and the essentially vertical application of force by the cyclist, the transmission of the applied force to the propulsion of the cycle varies approximately sinusoidally and is therefore quite inefficient.

US Patent No. 4831889 and UK Patent No. 2251586, both propose the use of drive shafts in place of multiple link chains.

US Patent No. 4831889 proposes the use of a varying diameter worm gear which is axially slidable in relation to a follower gear wheel to adjust the gear ratio. A simple bevel gear transmits the rotating pedal motion to the drive shaft. The power transmission of UK Patent No. 2251586 relies on frictional contact between a cylindrical

stub and a circular plate which is rotated by the circular motion of the pedals. Changes in gear ratio are achieved by alteration of the length of the drive shaft so that the cylindrical stub rests against the circular plate at varying distances from the axis of rotation of the circular plate. Both of these references, however, retain the use of a circular pedal motion.

French Patent Application No. 2703974 discloses two struts which are connected to a pair of foot depressed levers. As each lever is depressed, the corresponding strut rotates, thus driving a ratchetted gear wheel located on the axis of the driving wheel and connected thereto such as to drive the wheel. This device, however, still retains the rotational motion of the foot levers, albeit to a lesser extent, and thus retains the associated diminished efficiency.

An object, therefore, at least in an embodiment of the present invention, is to provide an improved cycle, having a more efficient drive mechanism.

According to the invention there is provided a drive assembly for a manually powered vehicle comprising a drive shaft, first and second elements which are, in use, alternately moved by manually applied forces thereto, first and second gears coupled to the drive shaft, means for coupling the first and second elements to the first and second gears and constraining means for constraining movement of the first and second elements to linear reciprocating movement.

The invention also provides a drive mechanism, suitable for use in a manually powered vehicle, comprising:

a drive shaft;

a first gear wheel mounted with respect to said drive shaft such that rotation of said gear wheel in a first direction imparts a drive force to said drive shaft and rotation of said gear wheel in the opposite direction is free-wheeling;

a first toothed rack co-operating with said gear wheel such that axial motion of the toothed rack causes rotational motion of the gear wheel; and

means associated with the toothed rack for manually driving the toothed rack in

direction, and vice versa. This link may be in the form of a cord passing over a pulley which is attached to the vehicle frame.

Preferably, the drive shaft is connected to a gearing mechanism for geared propulsion of the vehicle. This gearing mechanism may comprise a series of circular bevel gears positioned coaxially with respect to a driving wheel. In one embodiment, gear changes are effected by alteration of the length of the drive shaft to engage gears of different diameter.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic side view of a bicycle in accordance with an embodiment of the invention;

Figure 2 is a schematic partial perspective view of a transmission system in accordance with an embodiment of the invention.

Figure 3 is a schematic side view of a bicycle in accordance with a second embodiment of the invention;

Figure 4 is a view on an enlarged scale of the pedal configuration;

Figure 5 is a side view of the pedal configuration;

Figure 6 is a sectional view along the line 6–6;

Figure 7 is a sectional view along the line 7–7; and

Figure 8 is a sectional view along the line 8–8.

Figures 1 and 2 show a bicycle 10 constructed in accordance with a first embodiment of the invention. The bicycle includes a frame 26, front and rear wheels 25 and 27, handlebar 29 and saddle 31 which are constructed in a more or less conventional manner. The bicycle 10 has a novel drive assembly 11 constructed in accordance with a first embodiment of the invention. The drive assembly 11 includes toothed racks 14 and 16, gear wheels 18 and 20 and left and right pedals 22 and 24. The upper ends of the toothed racks 14 and 16 are connected by means of a cord which passes about an upper pulley 30 which, as seen in Figure 1, is connected to the frame 26 on the underside of the upper bar 33.

said axial motion;

whereby reciprocating axial motion of the toothed rack drives the drive shaft.

Preferably, the gear wheel is mounted on the drive shaft with a common axis of rotation, and a ratchet device permits the free-wheeling motion. The toothed rack can then be mounted adjacent the gear wheel so that teeth on the rack mesh with teeth on the external surface of the gear wheel.

The mechanism may be advantageously disposed in or on a manually powered vehicle wherein reciprocation of the toothed rack drives the vehicle. The toothed rack may be reciprocated by the application of force by either the hand or foot of a user to the means for driving the toothed rack. As such, the means for driving the toothed rack may be a hand grip or foot pedal.

Preferably, a second gear wheel and second toothed rack are similarly mounted in relation to the drive shaft so that a gear wheel and a tooth rack assembly is provided for each hand, or foot of the user.

In one application, the vehicle is a cycle and foot levers are provided on respective toothed racks for foot powered propulsion. In this application, the toothed racks are mounted on the cycle frame in a position generally below the seat such that a cyclist sitting on the seat is able to operate the means for driving the toothed racks with his or her feet. The drive shaft is operatively attached to the rear wheel of the cycle to drive the cycle.

Generally, in cycle applications, the toothed racks are positioned on either side of the drive shaft. In such cases, a supplementary gear wheel may be provided between one of the first and second gear wheels and the respective toothed rack, so that both toothed racks power the drive shaft in the same rotational direction.

Preferably, a link between the two toothed racks causes the first rack to be moved in the free-wheeling direction when the second rack is moved in the drive

The transmission of power to the drive shaft 12 from foot strokes applied to the pedals 22 and 24 can be more clearly seen in Figure 2. Gear wheels 18 and 20 are mounted on the drive shaft, the mounting including a ratchet mechanism so that the gear wheels 18 and 20 can rotate freely with respect to the drive shaft in a first direction (in this case clockwise) but when rotated in the opposite direction (in this case anti-clockwise) the gear wheels can apply a driving force to the drive shaft 12.

As can be seen in Figure 2, the toothed racks 14 and 16 are mounted one either side of the drive shaft 12. To correct the resulting opposite sense of rotation, a supplementary gear wheel 32 is mounted between the toothed rack 14 and the gear wheel 18. In this way, downward strokes of both pedals 22 and 24 result in driving force being applied through the gear wheels 18 and 20 to the drive shaft 12.

The toothed racks 14 and 16 are mounted in guides (not shown) allowing substantially vertical sliding motion of the toothed racks 14 and 16. As one toothed rack 14 and 16 moves downward, rotating the corresponding gear wheel 18 and 20 and thus driving the drive shaft, the other toothed rack is drawn upwards by the cord 28 and pulley 30 system to its original position, incurring little or no resistance due to the free-wheeling motion of the gear wheel corresponding to the upwardly moving toothed rack. A second cord 50 and pulley 52 can be provided at the lower end of the racks 14 and 16 to ensure proper movement of the racks 14 and 16, as shown in Figure 2. The pulley 52 can be supported by a bracket (not shown) connected to a lower part of the frame 26.

Although the gear wheels 18 and 20 are necessarily offset along the drive shaft 12, the pedals 22 and 24 may be appropriately offset to counter this, as shown in Figure 1.

Another advantage of this system is that it allows the possibility of adjusting the height of the pedals 22 and 24 to suit the individual user. This may be done either by adjusting the position of the pedals 22 and 24 on their respective toothed racks, or by adjusting the length of cord 28 connecting the two toothed racks. The method of

adjusting the position of the pedals 22 and 24 on the toothed racks 14 and 16 is preferred because in this way the relative position of the toothed racks and gear wheels is not affected.

In the embodiment of Figure 1, the drive shaft includes shaft length adjustor means 40. The rear end of the drive shaft 12 is provided with a bevel gear 42, and the rear wheel hub is provided with a series of corresponding circular bevel gears 44, 46 and 48. By adjusting the length of the drive shaft 12, different gears can be engaged to provide different gear ratios in accordance with the cycling conditions. Alternatively, other gearing arrangements, such as a gear box on the hub of the driven wheel, may be utilised.

In another embodiment (not shown), the angle of the sliding motion of the toothed racks may be adjusted, for example, so as to be in line with the seat support bar 34. In accordance with this embodiment of the invention, the direction in which force is applied to the pedal is substantially the same as the direction of movement of the toothed racks 14 and 16 required to provide torque to the gear wheels 18 and 20. Thus, a significantly higher percentage of the force applied to the pedals is directly transmitted to the drive shaft and thus to the propulsion of the bicycle when compared with conventional cycles.

Although not described here, the transmission system of the present invention may be utilised in many different forms of manually propelled vehicles. For example, the transmission may be put to use in such varied vehicles as manually propelled watercraft, foot-powered children's toy cars, or as an alternative transmission system in wheelchairs or the like. In the latter case the reciprocating motion of the toothed racks (or rack where only one is provided) may be facilitated by the provision of hand-grips on the toothed racks so that the transmission can be powered by hand.

Figures 3 to 8 illustrate a preferred embodiment of the invention. In these Figures, the same reference numerals have been used to denote corresponding parts where appropriate.

The embodiment of Figures 3 to 8 is analogous in its operation to that illustrated in Figures 1 and 2. In particular, the bicycle includes a drive assembly 60 in which the left and right pedals 22 and 24 are arranged for reciprocating motion rather than circular motion as is usually the case where the pedals are mounted on the ends of crank levers. As will be described in more detail below, the drive assembly 60 includes a chain 62 which is coupled to rotate the drive shaft 12 as well as perform the function of the return cords 28 and 50 of the previous embodiment.

In the drive assembly 60, the pedals 22 and 24 are mounted on support brackets 64 and 66 which are fixed to the chain. The chain 62 itself may comprise a normal bicycle chain but in accordance with the invention it is not continuously rotated but is reciprocated by means of the pedals 22 and 24. Accordingly, the brackets 62 and 64 can be fixedly connected to say three of the links in the chain without interfering with the required reciprocating motion. The chain could, alternatively, comprise two chain segments.

The chain 62 passes about upper and lower idler sprockets 68 and 70. The sprockets are mounted on sprocket axles 72 and 74 which are in turn mounted between forward and rear support plates 76 and 78 (the front support plate 76 being omitted for clarity of illustration in Figure 4). As best seen in Figure 3, the forward plate 76 is connected to a mounting boss 80 through which the lower bar 82 of the framework 26 passes. Means (not shown) is provided to fix the boss on the bar 82. The plates 76 and 78 include openings 84 through which the bar 82 passes. The plate 78 also includes an opening (not shown) through which the shaft 12 passes.

The drive assembly 60 includes first and second spur gears 86 and 88 which are located generally beside one another and between the plates 74 and 76, as best seen in Figures 4 and 8. The gears 86 and 88 mesh with one another. The gear 86 is mounted on a hub 90 which is connected to a shaft 92 which in turn is coupled to one end of the drive shaft 12, as seen in Figure 6. The shaft 92 is supported for rotation by means of bearings 94 and 96. The shaft 92, hub 90 and gear 86 are connected together by means of grub screws 98 for rotation in unison. Counter-clockwise rotation of the gear 86 will

cause counter-clockwise rotation of the shaft 12 for forward movement of the bicycle. A left hand drive sprocket 100 is mounted on the hub 90 by means of a sprag clutch 102. The teeth of the sprocket 100 engage the chain 62 and are driven thereby. When the right hand pedal 24 is moved downwardly, the right hand run of the chain 62 will engage the sprocket 100 and cause rotation of the hub 90. This in turn causes counter-clockwise rotation of the shaft 12 for propelling the bicycle. When, however, the right hand pedal moves upwardly the sprag clutch 102 will permit the sprocket 100 to rotate in the reverse direction without affecting the rotational movement of the hub 90.

As best seen in Figure 7, the gear 86 is mounted on a hub 104 which is mounted for rotation about a shaft 106 by means of bearings 108 and 110. The shaft 106 is mounted between the plates 74 and 76. A drive sprocket 112 is mounted on the hub 104 by means of a sprag clutch 114, the arrangement being such that when the sprocket 112 is rotated in a clockwise direction (as seen in Figure 4) driving torque is transmitted to the gear 88. The sprocket 112 is, however, free to rotate in the reverse direction without affecting the movement of the gear 88. The sprocket 112 is engaged by the left hand run of the chain 62 and the arrangement is such that when downward movement of the left hand pedal 22 occurs, driving forces are coupled through the sprocket 112 to the gear 88 and then to the gear 86. This in turn causes propelling movement of the shaft 12.

In use of the drive assembly 60, the rider of the bicycle presses alternately on the left and right pedals 22 and 24 to produce driving torque in the shaft 12. Each of the drive strokes is a substantially purely linear motion and therefore the rider therefore achieves maximum mechanical efficiency in transmitting effort to the drive assembly. The chain 62 passing about the upper and lower sprockets 68 and 70 ensures that the pedals are returned with an upward vertical stroke during the time when the opposite pedal is undergoing its downward driving stroke.

Means may be provided to ensure that the chain 62 properly engages the sprockets 100 and 112. This can be achieved by ensuring that sufficient tension is maintained in the chain 62 for this purpose. As is well known in the art, means may

be provided for taking up any slack in the chain. This may be accomplished by a resilient mounting of one or more of the sprockets for this purpose. Alternatively, idler sprockets (not shown) may be mounted either side of the sprockets 100 or 112 for ensuring that the chain 62 engages the drive sprockets.

The drive assembly 60 can, of course, be located within a housing so as to protect the various components from dust and dirt. Such housing would, of course, prevent the user's garments from being entangled in the drive mechanism.

With the embodiment illustrated in Figures 3 to 8 the dimensions can be chosen as appropriate. In one convenient embodiment for use with an adult bicycle the support plates 74 and 76 have a height of say 430mm and a width of say 130mm. The length of the stroke of the pedals 22 and 24 can be a maximum of say 330mm. The plates 76 and 78 can be separated by a distance of say 54mm. These dimensions can, of course, be varied to suit particular requirements.

Throughout this specification and the claims which follows, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The described arrangement has been advanced merely by way of explanation and many modifications may be made thereto without departing from the spirit and scope of the invention which includes every novel feature and combination of novel features herein disclosed.

CLAIMS:

1. A drive assembly (11,60) for a manually powered vehicle comprising a drive shaft (12), first and second elements (22,24) which are, in use, alternately moved by manually applied forces thereto, first and second gears (20,32,86,88) coupled to the drive shaft, means (14,16,62) for coupling the first and second elements to the first and second gears and constraining means (68,70) for constraining movement of the first and second elements to linear reciprocating movement.

2. A drive assembly as claimed in claim 1 wherein said means for coupling comprises first and second racks (14,16) which mesh with said first and second gears respectively.

3. A drive assembly as claimed in claim 2 wherein the second gear (32) is coupled to the drive shaft via a third gear (18).

4. A drive assembly as claimed in claim 2 or 3 including return means (28,50) for alternately causing the first and second elements to execute a return stroke when the other of the first and second elements is executing a drive stroke by manually applied forces thereto.

5. A drive assembly as claimed in claim 4 wherein said gears include clutch means which permit driving torques to be applied to the drive shaft when the elements are executing drive strokes and permit counter rotation of the gears during the return strokes.

6. A drive assembly as claimed in claim 1 wherein said means for coupling comprises a chain (62) which is coupled to first and second sprockets (112,100) which are coupled to said first and second gears respectively.

7. A drive assembly as claimed in claim 6 wherein the first and second sprockets are coupled to the first and second gears by means of clutches (114,102).

8. A drive assembly as claimed in claim 7 wherein the clutches comprise first and second sprag clutches (114,102) coupled between the first gear (86) and the first sprocket (112) and between the second gear (88) and the second sprocket (100) respectively.

9. A drive assembly as claimed in claim 8 wherein the sprag clutch permit driving torques to be applied to the drive shaft when the respective elements execute drive strokes.

10. A drive assembly as claimed in any one of claims 6 to 9 wherein the chain passes about first and second idler sprockets (68,70).

11. A drive assembly as claimed in claim 10 wherein the gears and sprockets are mounted between support plates (74,76).

12. A drive assembly as claimed in any preceding claim including mounting means (80) for mounting the drive assembly to a bicycle (10) and wherein said first and second elements comprise pedals.

13. A bicycle comprising a framework (26), front and rear wheels (25,27) and a drive assembly (11,60) as claimed in any preceding claim.

14. A bicycle as claimed in claim 13 wherein an end of the drive shaft has a drive gear (42) mounted thereon for driving a complementary gear or gears (44,46,48) mounted on the rear wheel.

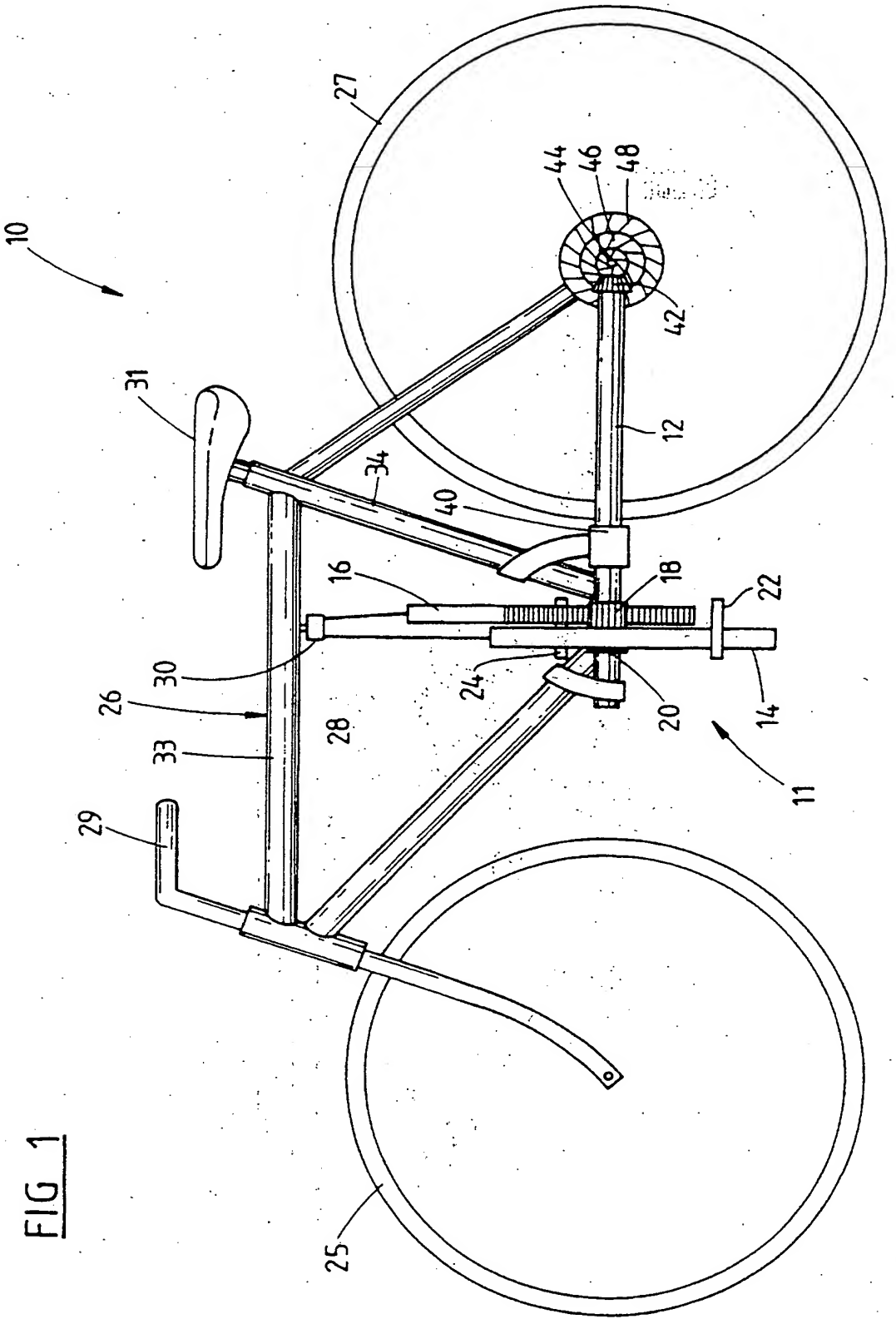


FIG 1

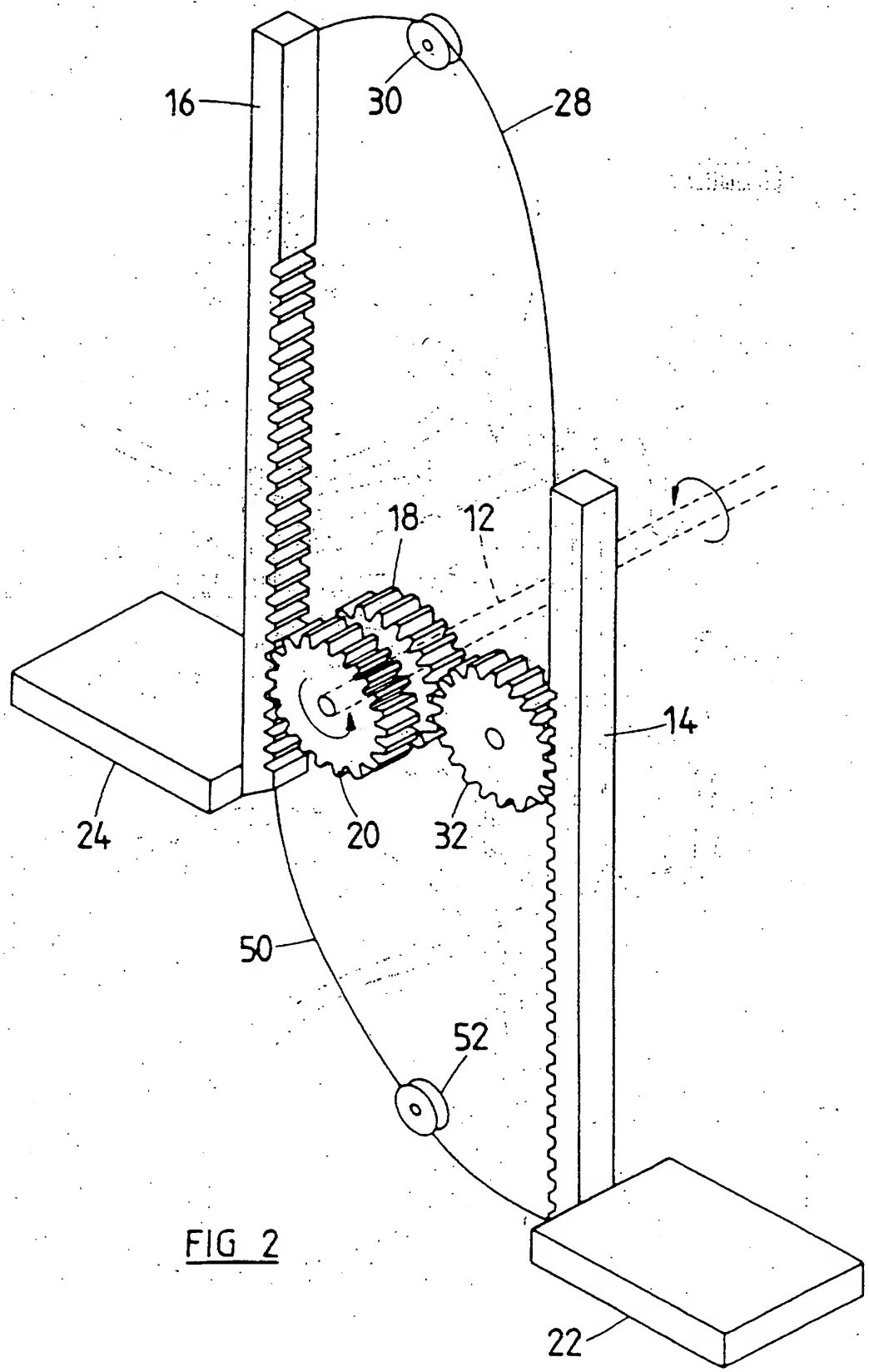


FIG 2

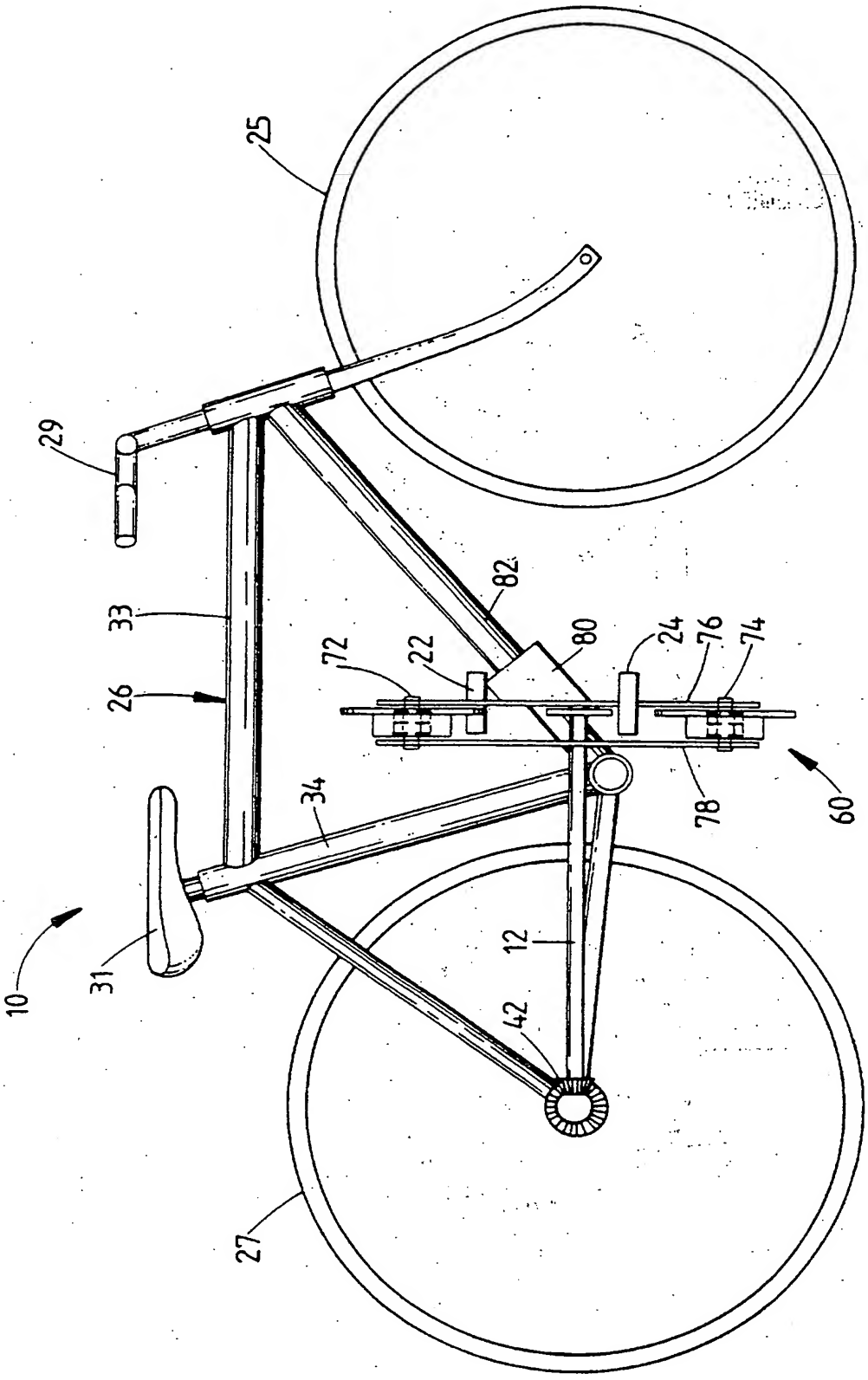


FIG 3

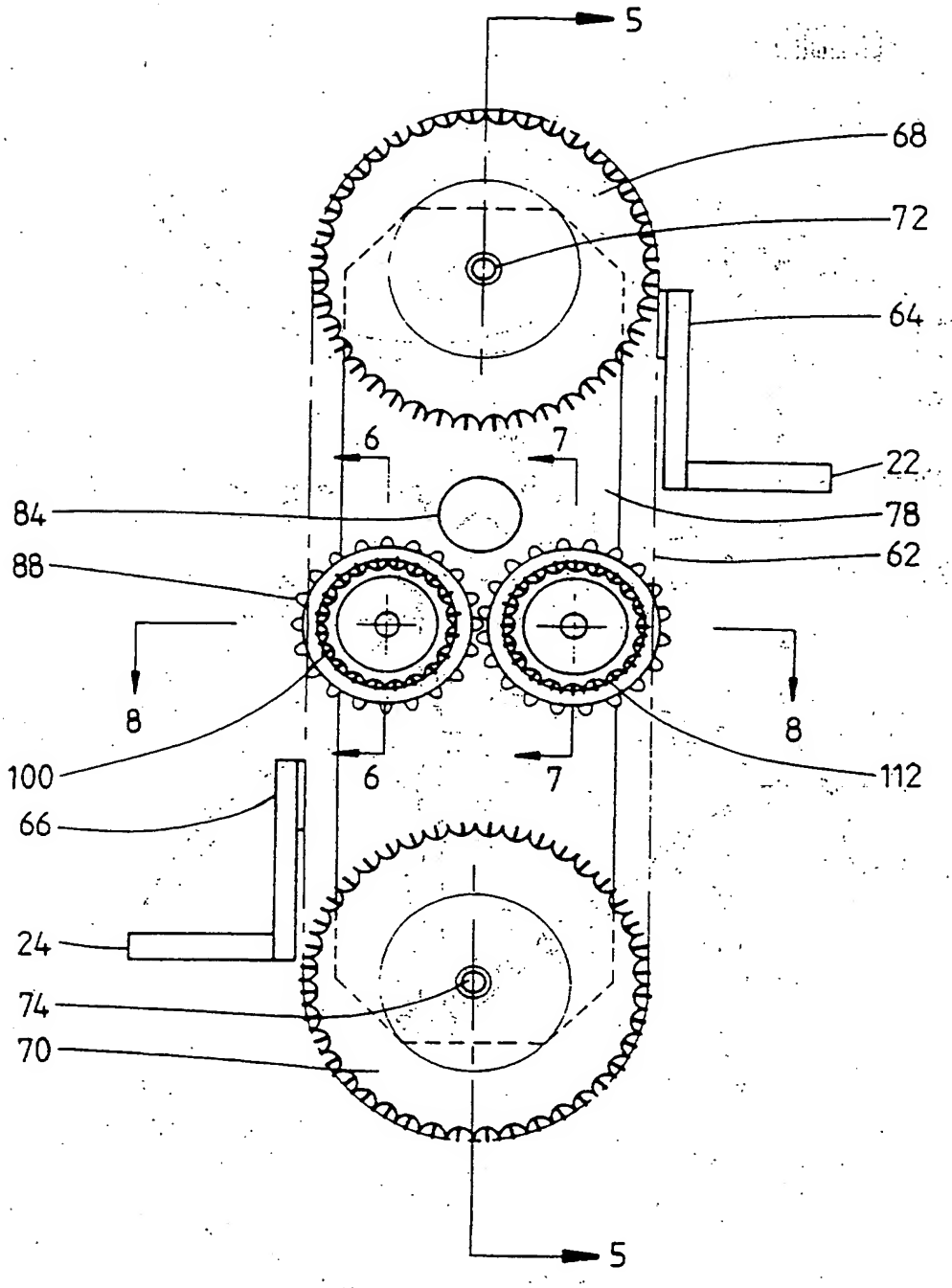


FIG 4

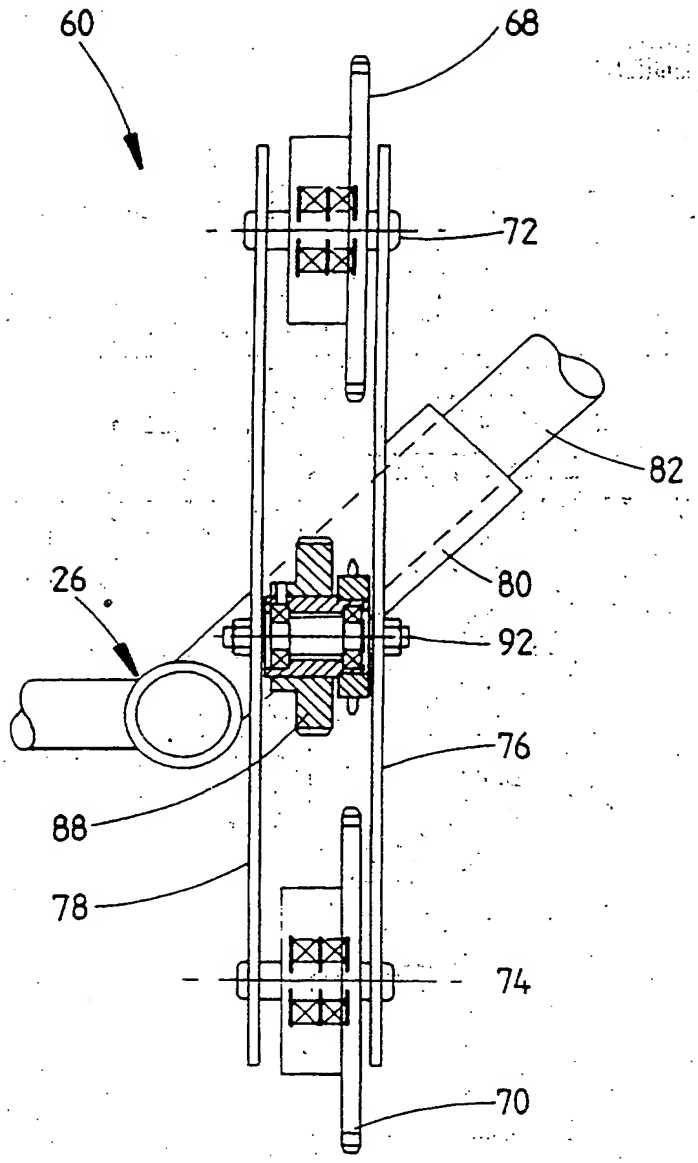


FIG 5

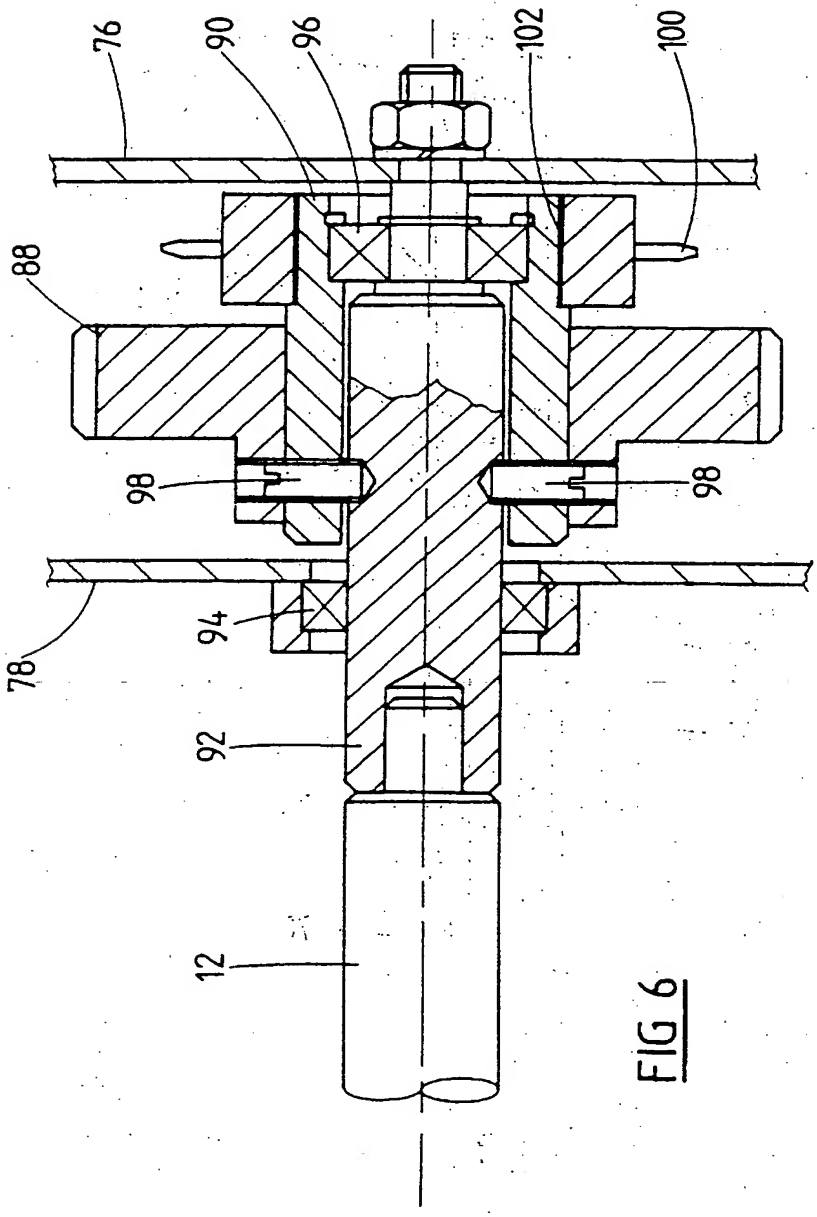


FIG 6

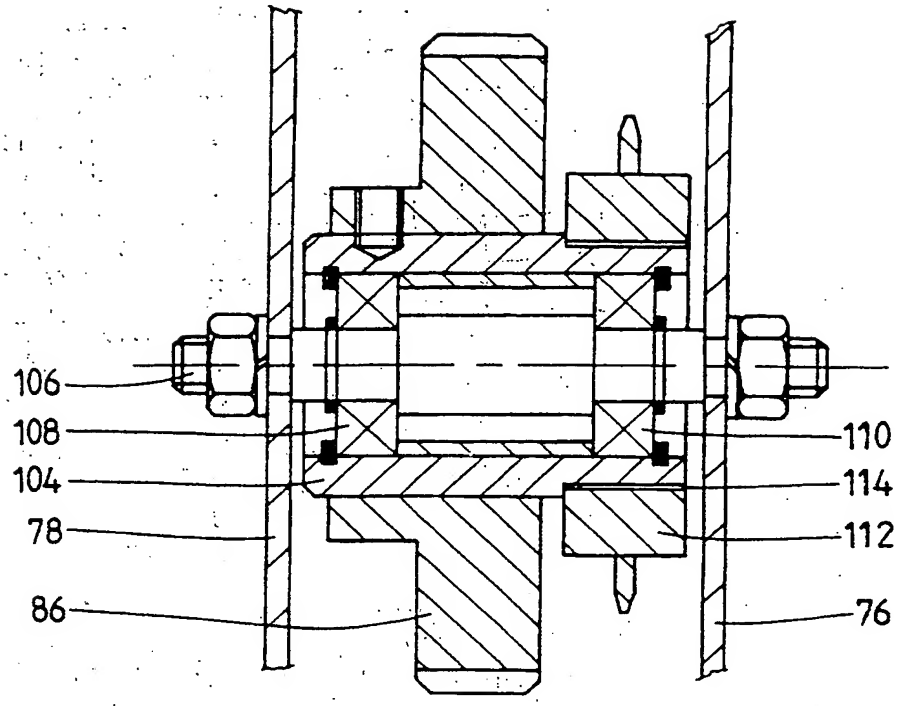


FIG 7

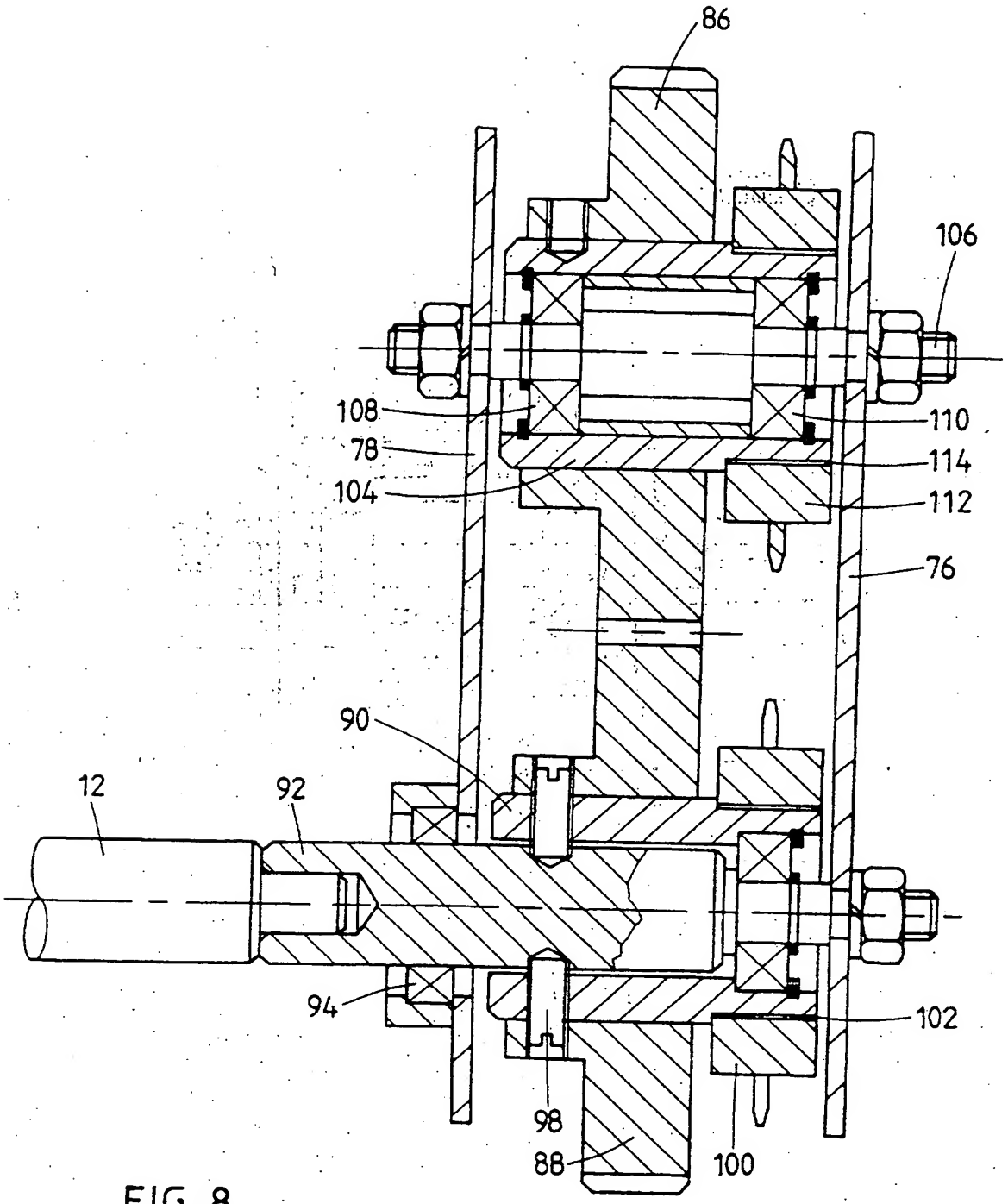


FIG 8

INTERNATIONAL SEARCH REPORT

International Application No.
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## A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: B62M 1/04, 11/02, 11/06

According to International Patent Classification (IPC) or to both national classification and IPC

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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|---|---|---|
| | Patent Abstracts of Japan, M1440, page 67, JP 5-50974 A (YOSHIHIRO AIDA) 2 March 1993 | |
| X | abstract and drawing | 1-4, 6, 11-14 |
| Y | | 5, 7-10 |
| | US 5236211 A (MEGUERDITCHIAN) 17 August 1993 | |
| X | whole document | 1, 6, 10-14 |
| Y | | 2, 4 |
| Y | line 65 column 5 to line 16 column 6 | 5 |
| | US 3 891 235 A (SHELLY) 24 June 1975 | |
| X | line 32 column 1 to line 17 column 4 | 1, 6, 10-14 |
| Y | | 2, 4, 5 |

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|---|---|---|
| X | US 2283 506 A (MONCADA) 19 May 1942<br>whole document and fig. 7 | 1, 2, 4, 12, 13 |
| X | FR 532533 A (LEGROUX) 6 February 1922<br>whole document | 1, 2, 4, 12-14 |
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